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CRETACEOUS FLORAS OF THE NORTHWEST TERRITORIES OF CANADA.

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GEOLOGICAL RELATIONS OF THE FLORAS.

IN my memoir in the First volume of the Transactions of this Society, I have given a table of the formations prepared by Dr. G. M. Dawson, and have fully stated the geological position of the plants at that time described. The new facts above detailed now require us to intercalate in our table three distinct plant horizons not previously recognized in the western territories of Canada. One of these, the Kootanie series, should probably be placed at the base of the table as a representative of the Urgonian or Neocomian, or, at the very least, should be held as not newer than the Shasta group of the United States Geologists, and the Lower Sandstones and Shales of the Queen Charlotte Islands. It would seem to correspond in the character of its fossil plants with the oldest Cretaceous floras recognized in Europe and Asia, and with that of the Komé formation in Greenland, as described by Heer. No similar flora seems yet to have been distinctly recognized in the United States, except, perhaps, that of the beds in Maryland, holding cycads, and which were referred many years ago by Tyson to the Wealden.

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[1] This paper states the general conclusions of a memoir, by Sir William Dawson, in the Transactions of the Royal Society of Canada, which will appear with descriptions and illustrations of the new species in the course of next winter.

The second of these plant horizons, separated according to Dr. G. M. Dawson, by a considerable thickness of strata, is that which he has called the Mill Creek series, and which corresponds very closely with that of the Dakota group, as described by Lesquereux, and that of the Atané and Patoot formations in Greenland, as described by Heer. This fills a gap indicated only conjecturally in the section of 1883. Along with the plants from the Dunvegan group of Peace River, described in 1883, it would seem to represent the flora of the Cenomanian and Senonian divisions of the Cretaceous in Europe.

Above this we have also to intercalate a third sub-flora, that of the Belly River series at the base of the Fort Pierre group. This, though separated from the Laramie proper by the marine beds of the Pierre and Fox Hill groups, more than 1,700 feet in thickness, introduced the Laramie or Danian flora, which continues to the top of the Cretaceous, and probably into the Eocene, and includes several species still surviving on the American continent, or represented by forms so close that they may be varietal merely.

Lastly: the subdivision of the Laramie group, in the last report of Dr. G. M. Dawson, into the three members known respectively as the Lower or St. Mary River series, the Middle or Willow Creek series, and the Upper or Porcupine Hill series, in connection with the fact that the fossil plants occur chiefly in the lower and upper members, enables us now to divide the Laramie flora proper into two sub-floras, an older, closely allied to the underlying Belly River series; and a newer, identical with that of Souris River, described as Laramie in Dr. G. M. Dawson's Report on the 48th Parallel, 1876, and in the Report of the Geological Survey of Canada for 1879, and which appears to agree with that known in the United States as the Fort Union group, and with the so-called Miocene of Heer from Greenland.

From the animal fossils and the character of the flora, it would seem probable that the rich flora of the Cretaceous coal fields of Vancouver Island is nearly synchronous with that of the coal-bearing Belly River series of the western plains.

It will thus be seen that the explorations already made in Canadian territory have revealed a very complete series of Cretaceous plants, admitting, no doubt, of large additions to the number of species by future discoveries, and also of the establishment of connecting links between the different members, but giving a satisfactory basis for the knowledge of the succession of plants and for the determination of the ages of formations by their vegetable fossils.

The successive series may be tabulated as follows, with references for details to the fuller table in my memoir of 1883:—

SUCCESSIVE FLORAS AND SUB-FLORAS OF THE CRETACEOUS IN CANADA.

(IN DESCENDING ORDER.)

PERIODS.	FLORAS AND SUB-FLORAS.	REFERENCES.
Danian	Upper Laramie and Porcupine Hill Series	Platanus beds of Souris River and Calgary. Report Geol. Survey of Canada for 1879, and present memoir.
	Middle Laramie or Willow Creek Series.	
	Lower Laramie or St. Mary River Series	Lemna and Pistia beds of bad lands of 49th Parallel, Red Deer River, etc., with Lignites. Report 49th Parallel and this memoir.
Senonian	Fox Hill Series	Marine.
	Fort Pierre Series	Marine.
	Belly River Series. (See note)	Sequoia and Brasenia beds of S. Saskatchewan, Belly River, etc., with Lignites. This memoir.
	Coal Measures of Nanaimo, B.C., probably here	Memoir of 1883. Many Dicotyledons, Palms, etc.
Cenomanian	Dunvegan Series of Peace River. (See note)	Memoir of 1883. Many Dicotyledons, Cycads, etc.
	Mill Creek Series of Rocky Mountains	Dicotyledonous leaves, similar to Dakota Group of the U. S. This memoir.
Neocomian & Urgonian	Suskwa River and Queen Charlotte Island Series. Intermediate Series of Rocky Mountains	Cycads, Pines, a few Dicotyledons. Report Geol. Survey. This memoir.
	Kootanie Series of Rocky Mountains	Cycads, Pines and Ferns. This memoir.

NOTE.—Though the flora of the Belly River Series very closely resembles that of the Lower Laramie, showing that similar plants existed throughout the Senonian and Danian periods in North America, yet it is to be anticipated that specific differences will develop themselves in the progress of discovery. In the meantime it scarcely seems possible to distinguish by fossil plants alone the Lower Laramie beds from those of Belly River, and if these are really separated by 1,700 feet of marine strata, as is now believed on stratigraphical grounds, the flora must have been remarkably persistent. The Dunvegan series of Peace River probably corresponds in time with the Marine Niobrara Group farther South.

In connection with the above table it should be understood that Tertiary floras, probably Miocene in age, are known in the interior of British Columbia, though they have not yet been recognized in the territories east of the Rocky Mountains.

Before leaving this part of the subject I would deprecate the remark which I see occasionally made, that fossil plants are of little value in determining geological horizons in the Cretaceous and Tertiary. I admit in these periods some allowance must be made for local differences of station, and also that there is a generic sameness in the flora of the Northern Hemisphere, from the Cenomanian to the modern, yet these local differences and general similarity are not of a nature to invalidate inferences as to age. No doubt palæobotanists seem obliged, in deference to authority, and to the results of investigations limited to a few European localities, to group together, without distinction, all the floras of the later Cretaceous and earlier Tertiary, irrespective of stratigraphical considerations, the subject lost its geological importance. But when a good series has been obtained in any one region of some extent, the case becomes different. Though there is still much imperfection in our knowledge of the Cretaceous and Tertiary floras of Canada, I think the work already done in Canada in connection with that of Lesquereux and Newberry in the United States, is sufficient to enable any competent observer to distinguish by their fossil plants the Lower, Middle and Upper Cretaceous, and the latter from the Tertiary.

PHYSICAL CONDITIONS AND CLIMATE INDICATED BY THE CRETACEOUS FLORAS.

In the Jurassic and earliest Cretaceous periods the prevalence, over the whole of the Northern Hemisphere and for a long time, of a monotonous assemblage of gymnospermous and Acrogenous plants, implies a uniform and mild climate and facility for intercommunication in the north. Toward the end of the Jurassic and the beginning of the Cretaceous, the land of the Northern Hemisphere was assuming greater dimensions, and the climate probably becoming a little less uniform. During the close of this period or at the beginning of the next, the dicotyledonous flora seems to have been introduced, under geographical conditions which permitted a warm temperate climate to extend as far north as Greenland.

In the Cenomanian, we find the Northern Hemisphere tenanted with dicotyledonous trees closely allied to those of modern times, though still indicating a climate much warmer than that which at present prevails. In this age, extensive but gradual submergence of land is indicated by the prevalence of chalk and marine limestones over the surface of both continents; but a circumpolar belt of land seems to have been maintained, protecting the Atlantic and Pacific basins from floating ice, and permitting a temperate flora of great richness to prevail far to the north, and especially along the southern margins and extensions of the circumpolar land. These seem to have been the physical conditions which terminated the existence of the old Mesozoic Flora and introduced that of the Middle Cretaceous.

As time advanced, the quantity of land gradually increased, and the extension of new plains along the older ridges of land was coincident with the deposition of the great Laramie series, and with the origination of its peculiar flora, which indicates a mild climate and considerable variety of station in mountain, plain and swamp, as well as in great sheets of shallow and weedy fresh water.

In the Eocene and Miocene periods the continent gradually assumed its present form, and the vegetation became still more modern in aspect. In that period of the Eocene, however, in which the great nummulitic limestones were deposited, a submergence of land occurred on the Eastern continent which must have assimilated the physical conditions to those of the Cenomanian. This great change, affecting materially the flora of Europe, was not proportionately great in America, which also by the north and south extension of its mountain chains permitted movements of migration not possible in the Old World. From the Eocene downwards, the remains of land animals and plants are found only in lake basins occupying the existing depressions of the land, though more extensive than those now existing. It must also be borne in mind, that the great foldings and fractures of the crust of the earth which occurred at the close of the Eocene, and to which the final elevation of such ranges as the Alps and the Rocky Mountains belongs, permanently modified and moulded the forms of the continents.

These statements raise, however, questions as to the precise equivalence in time of similar floras found in different latitudes. However equable the climate, there must have been some appreciable difference in proceeding from north to south. If, therefore, as seems in every way probable, the new species of plants originated on the Arctic land and spread themselves southward, this latter process would occur most naturally in times of gradual refrigeration or of the access of a more extreme climate, than is in times of the elevation of land in the temperate latitudes, or conversely, of local depression of land in the Arctic, leading to invasions of northern ice. Hence the times of the prevalence of particular types of plants in the far north would precede those of their extension to the south, and a flora found fossil in Greenland might be supposed to be somewhat older than a similar flora when found farther south. It would seem, however, that the time required for the extension of a new flora to its extreme geographical limit, is so small in comparison with the duration of an entire geological period that practically, this difference is of little moment, or at least does not amount to antedating the Arctic flora of a particular type by a whole period, but only by a fraction of such period.

It does not appear that during the whole of the Cretaceous and Eocene periods there is any evidence of such refrigeration as seriously to interfere with the flora, but perhaps the times of most considerable warmth are those of the Dunvegan group in the Middle Cretaceous and those of the later Laramie and Palæocene.

It would appear, that no cause for the mild temperature of the Cretaceous needs to be invoked, other than those mutations of land and water which the geological deposits themselves indicate. A condition for example of the Atlantic basin in which the high land of Greenland should be reduced in elevation and at the same time the northern inlets of the Atlantic closed against the invasion of Arctic ice, would at once restore climatic conditions allowing of the growth of a temperate flora in Greenland. Dr. Brown has shown,[1] and, as I have elsewhere argued, the absence of light in the Arctic winter is no disadvantage, since, during the winter, the growth of deciduous trees is in any case suspended, while the constant continuance of light in the summer is, on the contrary, a very great stimulus and advantage.

[1] Florula Discana.

It is a remarkable phenomenon in the history of the genera of plants in the later Mesozoic and Tertiary, that the older genera appear at once in a great number of specific types, which become reduced as well as limited in range down to the modern. This is, no doubt, connected with the greater differentiation of local conditions in the modern; but it indicates also a law of rapid multiplication of species in the early life of the genera. The distribution of the species of *Salisburia, Sequoia, Platanus, Sassafras, Liriodendron, Magnolia,* and many other genera, affords remarkable proofs of this.

Gray, Saporta, Heer, Newberry, Lesquereux and Starkie Gardner, have all ably discussed these points; but the continual increase of our knowledge of the several floras, and the removal of error as to the dates of their appearance, must greatly conduce to clearer and more definite ideas. In particular, the prevailing opinion that the Miocene was a period of great extension of warmth and of a temperate flora into the Arctic, must be abandoned in favor of the later Cretaceous and Eocene; and if I mistake not, this will be found to accord better with the evidence of general geology and of animal fossils.